The Influence of Religion on Alcohol Use Initiation: Evidence for Genotype X Environment Interaction

Koopmans, J.R.; Slutske, W.S.; van Baal, G.C.M.; Boomsma, D.I.

published in
Behavior Genetics
1999

DOI (link to publisher)
10.1023/A:1021679005623

document version
Publisher's PDF, also known as Version of record

Behavior Genetics, Vol. 29, No. 6, 1999

The Influence of Religion on Alcohol Use Initiation: Evidence for Genotype X Environment Interaction

Judith R. Koopmans,[1,3] Wendy S. Slutske,[2] G. Caroline M. van Baal,[1] and Dorret I. Boomsma[1]

Received 2 June 1999—Final 4 Nov. 1999

We examined the possible role of religious upbringing as a mediator of the shared environmental influences and as a moderator of the genetic influences on the risk of alcohol use initiation in a large population-based sample of Dutch adolescent and young adult twins (1967 twin pairs). There was not a significant association between religious participation and alcohol use initiation among Dutch adolescents and young adults. We also hypothesized that the relative magnitude of the genetic influences on the risk of alcohol use initiation would be greater for those adolescents and young adults who were raised in a less religious environment compared to those adolescents and young adults who were raised in a more religious environment. We indeed found higher heritabilities for females without a religious upbringing compared to females with a religious upbringing. Genetic influences accounted for 40% of the variance in alcohol use initiation in nonreligious females, compared to 0% in religiously raised females. Shared environmental influences accounted for 54% of the variance for nonreligious females and 88% of the variance in religious females. For males, the genetic variance was also higher in the nonreligious group compared to the religious group, but this difference was not statistically significant. Whether or not they were raised religiously, the liability to alcohol use initiation in males was moderately influenced by genetic factors (30%) and substantially influenced by shared environmental factors (60%).

KEY WORDS: Religion; alcohol use initiation; genotype X environment interaction; Dutch twins.

INTRODUCTION

Twin studies have generally been consistent in suggesting that there are important family environmental influences on whether or not one chooses to drink alcohol (Han *et al.,* 1999; Heath and Martin, 1988; Koopmans *et al.,* 1996; Loehlin, 1972; Maes *et al.,* 1999; Rose *et al.,* 1999). Estimates of the proportion of variation in alcohol use initiation due to shared family environmental influences from four recent general population twin studies ranged from 37% among 805 17- to 25-year-old Dutch twin pairs (Koopmans *et al.,* 1996), 46% among 501 17- to 18-year-old Minnesota-born twin pairs (Han *et al.,* 1999), 53–71% among 571 13- to 16-year-old Virginia twin pairs (Maes *et al.,* 1999), 58–88% among 403 15- to 16-year-old Dutch twin pairs (Koopmans *et al.,* 1996), and approximately 75% among 2711 16 year-old Finnish twin pairs (Rose *et al.,* 1999). Family environmental influences are at least as important as, if not more important than, genetic influences in determining the risk for initiating alcohol use among adolescents and young adults.

Religiosity is a likely candidate as an important mediator of the shared environmental influences on the initiation of alcohol use for two reasons. First, some studies have found that religiosity itself is explained almost entirely by shared family environmental influences (Boomsma *et al.,* 1999; Eaves *et al.,* 1990; Heath *et al.,* 1999), at least among those of European ances-

[1] Free University, Amsterdam, The Netherlands.
[2] University of Missouri, Columbia, Missouri 65211.
[3] To whom correspondence should be addressed at Department of Biological Psychology, De Boelelaan 1111, 1081 HV Amsterdam, The Netherlands. Fax: +31.20.444.8832. e-mail: jr.koopmans@psy.vu.nl.

0001-8244/99/1100-0445$16.00/0

try (Heath *et al.*, 1999). Second, in epidemiological studies conducted in both the United States and Australia religious affiliation and participation is significantly associated with abstinence from alcohol (Amey *et al.*, 1996; Heath and Martin, 1988; Heath *et al.*, 1999; Maes *et al.*, 1999; Midanik and Clark, 1994). In a nationally representative sample of 2058 adults in the United States, 49% of conservative Protestant individuals, compared to 27% of liberal Protestant individuals and 21% of Catholic individuals, reported that they were abstinent from alcohol in the past year (Midanik and Clark, 1994). In the same survey, 48% of individuals who reported that religion was "very important," compared to 22% of individuals who reported that religion was "not at all important," were abstinent from alcohol in the past year. These same associations among religious affiliation, religious participation, and abstinence from alcohol have also been observed in a representative sample of 9873 Caucasian teenagers in the United States (Amey *et al.*, 1996). For example, 59% of high school seniors who reported that religion was "very important," compared to 36% of high school seniors who reported that religion was "not at all important," were lifetime abstainers from alcohol (Amey *et al.*, 1996).

Religiosity may also play an important role in influencing the risk of alcohol use initiation as a moderator of genetic influences (i.e., genotype X environment interaction). Heath *et al.* (1985) demonstrated how the relative magnitude of genetic influences on a behavioral outcome (such as educational attainment) may be attenuated in environments in which choices are more limited by external factors (such as society or one's family), compared with environments in which individuals have more personal choices. Three examples of genotype × environment interaction for alcohol-related outcomes can be found in the behavioral genetic literature. Heath *et al.* (1989) found that the relative magnitude of genetic influences on total weekly alcohol consumption in unmarried female twins was significantly greater than among married female twins. A possible interpretation of this result is that genetic influences on alcohol consumption among married women are attenuated because the decision to drink is based less on personal choice (innate characteristics of the individual) and based more on family circumstances (external to the individual) than among unmarried women. Rose *et al.* (1999) found that the relative magnitude of genetic influences on alcohol use initiation was significantly greater among adolescents living in urban Greater Helsinki than among adolescents living in rural northern Finland. Rose *et al.* (1999) presented several interpretations of this finding consistent with Heath's (1985) environmental attenuation of genetic influences hypothesis, such as regional differences in availability of alcohol, control of adolescent drinking, exposure to alcohol-drinking peers, and religiosity. Boomsma *et al.* (1999) directly tested the role of religiosity as a moderator of genetic influences on behavioral disinhibition (using a subscale from Zuckerman's Sensation Seeking Scale). Genetic influences on behavioral disinhibition were significantly greater among those who reported less religious involvement than among individuals who reported greater religious involvement. [Previously, we found that alcohol use and disinhibition were significantly correlated (r = .46 and .41 in males and females, respectively (Koopmans *et al.*, 1997).] An interpretation similar to that of the studies by Heath *et al.* (1989) and Rose *et al.* (1999) can also be advanced—that is, that genetic influences on disinhibited behavior (including the use of alcohol and drugs) among more religious individuals are attenuated because one's decision on how to behave is based less on personal choice and more by family circumstances or religious proscriptions than among less religious individuals.

The results of Heath *et al.* (1989), Rose *et al.* (1999), and Boomsma *et al.* (1999) suggest that there may be specific environmental contexts in which the genetic influences on the risk for alcohol use initiation among teenagers and young adults may be more pronounced than is suggested by the previous research. In the present study, we examined the possible role of religious participation as a mediator of the shared environmental influences and as a moderator of the genetic influences on the risk of alcohol use initiation in a large population-based sample of Dutch adolescent and young adult twins. We hypothesized that (a) a significant association between religious participation and alcohol use initiation would be obtained among Dutch adolescents and young adults, and (b) the relative magnitude of the genetic influences on the risk of alcohol use initiation will be greater for those adolescents and young adults who were raised in a less religious environment compared to those adolescents and young adults who were raised in a more religious environment.

METHODS

Subjects

This study is part of a longitudinal questionnaire study that has assessed Dutch families with adolescent

and young-adult twins every 2 years beginning in 1991. The data presented in this paper come from the second (1993) survey, which was sent to families who had participated in the study in 1991 (49% of the sample) and also to newly recruited families. Addresses from twins were obtained from City Council registries (Boomsma *et al.,* 1994; Koopmans *et al.,* 1996). The total number of participating families was 1974. There were 1768 fathers (average age, 48 years), 1918 mothers (average age, 46 years), and 1967 twin pairs (average age, 17.8 years; SD = 3.1 years; range = 12–26 years) who completed the questionnaires. Thirty-two percent of the twins were 12–15 years old, 22% were 16–17 years old, and 46% of the twins were 18 years of age and older (see Table I).

For the majority of the twin pairs zygosity was determined from questions about physical similarity and confusion of the twins by family members, friends, and strangers. For 161 same-sex twin pairs information on their zygosity was available from blood group and/or DNA polymorphisms. The agreement between zygosity diagnosis from questionnaire and DNA data was 90% (in a larger group of 405 same-sex twin pairs of the same age who participated in other research projects, the agreement between DNA/blood group polymorphisms and questionnaire data on zygosity was 95%). The zygosity of the twins was 40% MZ and 60% DZ, with a nearly equal participation of male and female twins [MZM=327 (17%), MZF=457 (23%) DZM=284 (14%) DZF=356 (18%) DOS=543 pairs (28%)].

Measures

In 1993, subjects received an 18-page booklet that contained a large number of personality inventories, items about religion, zygosity, schooling, socioeconomic status, family structure, health, and questions about physical exercise habits, use of tobacco, use of alcohol and alcohol problems, and use of soft and hard drugs. We used an item about religious upbringing (no/yes) to assess the influence of religion on risk of alcohol use initiation. Half of the sample of twins (52%) reported that they were raised religiously. The interrater reliability of this item, as indexed by the association between cotwins' reports of their upbringing, was very high. Ninety-three percent of twin pairs agreed about whether or not they were raised religiously ($\kappa = .86$). Religious upbringing was strongly inversely correlated with reporting a current religious affilation as "none" ($\phi = -.74$). Nearly 80% of individuals without a religious upbringing reported no current religious affiliation, compared to only 5% of individuals with a religious upbringing (Boomsma *et al.,* 1999). Fifty-one percent of individuals with a religious upbringing reported that they were currently active in church activities, 37% reported that they were religious but not currently active in church activities, and a minority, 12%, reported that they were not religious and not currently active in church activities. In contrast, less than 1% of individuals without a religious upbringing reported that they were currently active in church activities, 10% reported that they were religious but not currently active in church activities, and the majority, 89%, reported that they were not religious and not currently active in church activities (Boomsma *et al.,* 1999). The twins were fairly representative of the Dutch population with respect to religious affiliation (Boomsma *et al.,* 1999).

Initiation of alcohol use was assessed with the question, 'Have you ever used alcohol?" The response categories were "no," "a few times to try," and "yes." Those who answered "a few times to try," were recoded into "no." Overall, 70% of males and 62% of females reported that they had ever used alcohol. The rates of alcohol use in this twin sample are comparable to the rates reported for Dutch adolescents and young adults in the general (nontwin) population (Table I). In a national survey of health-related behaviors of 5693 subjects conducted in The Netherlands in 1990, 77% of 16- to 17-year-old males and 87% of 18- to 24-year old males reported that they had ever used alcohol (CBS, 1999). In our sample the percentages of male drinkers for these two ages groups were 76 and 92%, respectively. For females, percentages of drinkers were somewhat higher in the twin sample compared to the census data (71 versus 63% for 16–17 year olds, 85 versus 78% for 18–24 year olds).

Statistical Analyses

The relative contribution of genetic and environmental factors to individual differences in alcohol use initiation can be analyzed with data gathered in genetically informative samples such as MZ and DZ twins (Neale and Cardon, 1992). MZ twins are genetically identical, while DZ twins share on average 50% of their segregating genes. If genes contribute to individual differences in alcohol use initiation, then the genetic similarity of MZ twins should make them more similar for alcohol use initiation than DZ twins. Quantifying the genetic and environmental factors that contribute to a dichotomous variable such as alcohol use initiation is possible by assuming that the trait under consideration has

Table I. Percentage of Alcohol Users in the Total Sample as a Function of Sex and Age

	12–15 years	16–17 years	18–24 years
Males			
Total number of subjects	557	361	791
Alcohol users in sample	35%	76%	92%
Alcohol users in 1990 census	n.a.	77%	87%
Females			
Total number of subjects	673	467	987
Alcohol users in sample	27%	71%	85%
Alcohol users in 1990 census	n.a.	63%	78%

Note. Census data were collected in 1990 from 5693 subjects aged 16 years and older (Centraal Bureau voor de Statistiek, 1999). n.a., not available.

an underlying continuous distribution, termed the liability (Falconer, 1989). This normal liability distribution is assumed to be influenced by the additive effects of multiple genetic and environmental factors. Thresholds divide the distribution into discrete categories. A person exceeds a threshold due to the effects of the latent factors that influence the liability to alcohol use initiation. In the case of a dichotomous variable such as alcohol use initiation, one threshold is estimated giving the proportion of abstainers and alcohol users in the sample. For a dichotomous variable, the correlation in liability, between members of a twin pair for example, is called the tetrachoric correlation. The tetrachoric correlations and the thresholds were estimated by the method of maximum likelihood with Mx (Neale, 1997), under the assumption that the joint distributions of twin pairs for the liability are bivariate normal. Alcohol use initiation (no/yes) in the firstborn twin was cross-classified with initiation in the second-born twin, resulting in 2×2 contingency tables for each zygosity group (monozygotic male and female twins, dizygotic same-sex and opposite-sex twins). In opposite-sex twins, data were reordered so that alcohol use initiation in males was cross-classified with alcohol use initiation in females.

Sex differences in prevalences were tested in Mx using the 2×2 contingency tables cross-classifying the alcohol use status of the first twin with the alcohol use status of the second twin. While constraining the total variances in alcohol use initiation to unity for males and females, a test of possible prevalence differences was conducted by equating the thresholds across sex, separately for the religious and nonreligious groups, and examining whether this produced a significant decrease in the goodness of fit of the model. Similarly, differences in prevalences of alcohol use initiation for the more religious versus less religious groups were tested by constraining the variances to unity in both the religious and the nonreligious groups and examining whether it was possible to equate the thresholds across groups, separately for males and females.

To test for G×E interaction the sample was divided into pairs in which both twins reported a religious upbringing (945 pairs) and pairs in which both twins reported that they received a nonreligious upbringing (837 pairs). The pairs (131) who did not agree on the answer on the question about religious upbringing and the pairs in which only one of the twins (42) or neither twin (19) answered the question about religious upbringing were omitted from the analyses.

Genetic analyses were carried out simultaneously on the data from male and female MZ and DZ and opposite-sex DZ twin pairs, with and without a religious upbringing (10 groups). Additive genetic effects (A), environmental effects common to offspring growing up together in the same family (C), and unique environmental effects (E) were estimated conditional upon sex and religious upbringing. When there is no G×E interaction, the estimates for the genetic and environmental effects should not vary between groups with and groups without a religious upbringing. There is evidence for G×E interaction when the estimates for the proportion of genetic variance differs between groups. Different estimates of the amount of variance in risk for alcohol use initiation that can be explained by genetic factors between groups with and groups without a religious upbringing imply that religious upbringing acts as a modifier of genetic effects on alcohol use initiation risk.

Model-fitting was done directly on the contingency tables in Mx. For both males and females, the total variance of the religious group was constrained to be unity.

Table II. Prevalence of Alcohol Use Initiation as a Function of Religious Upbringing (Number of Subjects in Parentheses)

	Males		Females	
	Religious	Nonreligious	Religious	Nonreligious
No	17.2% (141)	12.9% (97)	18.6% (196)	17.7% (161)
Few times	14.6% (120)	14.8% (111)	20.4% (216)	18.4% (168)
Yes	68.1% (559)	72.3% (542)	61.0% (644)	63.9% (583)

Thus, the phenotypic liability for the religious group is scaled as a standard normal. The area under the curve from the threshold to positive infinity gives the population prevalence. By constraining the thresholds to be equal between the religious and the nonreligious groups and allowing the total variance of the nonreligious group to take its own value, the prevalence of alcohol use initiation can differ between religious and nonreligious individuals. In this way it is also possible to test for nonscalar group differences in the genetic and environmental variances with bivariate data. In the most general model 12 parameters were estimated: h_{rm} and c_{rm}, and h_{rf} and c_{rf}, which represent the genetic and shared environmental influences on alcohol use initiation in the religious group, for males and females, respectively (the unique environmental factor is not a free parameter because the total variance is constrained to unity in the religious group); h_{nrm}, c_{nrm}, and e_{nrm}, and h_{nrf}, c_{nrf}, and e_{nrf}, to estimate the contribution of the latent factors in the nonreligious group, separately for males and females; and t_m and t_f, the thresholds for males and females, to allow for sex differences in prevalences.

For both males and females, four hypotheses were tested by comparing the fit of a reduced model to the fit of the most general full model described above: (a) whether there were differences in the genetic and shared environmental variances for the religious and nonreligious groups (by constraining the unique environmental variance across the religious and nonreligious groups); (b) whether there were differences in the genetic variances for religious and nonreligious groups (by constraining the shared and unique environmental variances across the religious and nonreligious groups); (c) whether there were differences in the unique environmental variances for the religious and nonreligious groups, that is, equal familial variance (by constraining the genetic and shared environmental variances across the religious and nonreligious groups; and (d) whether there were no differences in the genetic, shared environmental, and unique environmental variance, that is, no interaction (by constraining all three variances across the religious and nonreligious groups). Parameters were estimated by maximum-likelihood methods in Mx, giving an overall chi-square test of goodness of fit of the model (Neale, 1997). The fit of different nested models was assessed by likelihood-ratio chi-square tests.

RESULTS

The sample of twins was divided into two groups based on self-reported religious upbringing to explore the effects of religion on the genetic architecture of initiation of alcohol use. Table II shows the prevalence of drinking initiation for males and females with and without a religious upbringing. After recording the catergory "few times to try" into "no," sex differences in prevalences were tested in Mx using the 2 × 2 contingency tables cross-classifying the alcohol use status of the first twin with the alcohol use status of the second twin. For both the religious and the nonreligious groups, it was not possible to constrain the thresholds to be equal for males and females [$\Delta\chi^2(2) = 24.95$, $p < .01$].

There was a tendency for individuals with a religious upbringing to be less likely to initiate alcohol use compared to individuals without a religious upbringing. However, for both males and females, the thresholds could be constrained to be equal for the religious and nonreligious groups [$\Delta\chi^2$ (1) = 1.39 and $\Delta\chi^2(1) = 2.26$ for males and females, respectively]. Thus, the difference in the prevalences of alcohol use initiation between the religious and the nonreligious subjects was not significant.

Table III shows the concordances and the tetrachoric correlations for alcohol use initiation for each zygosity group as a function of religious upbringing. The high resemblance of DZ twins compared to MZ twins confirms our earlier finding of important shared environmental influences on the risk of alcohol use initiation (Koopmans *et al.*, 1996). In males, tetrachoric correlations were somewhat higher and differences between MZ and DZ twins seem to be smaller in the religious group compared to the nonreligious group,

Table III. Concordances and Tetrachoric Correlations (with 95% Confidence Intervals) for Alcohol Use Initiation as a Function of Religious Upbringing

	Religious				Nonreligious			
	Number of twin pairs				Number of twin pairs			
	Neither	One	Both	Correlation	Neither	One	Both	Correlation
MZM	40	17	95	0.93 (0.84–0.98)	34	21	92	0.88 (0.75–0.95)
DZM	31	22	71	0.82 (0.66–0.92)	18	29	73	0.61 (0.34–0.79)
MZF	77	37	114	0.87 (0.77–0.93)	73	20	99	0.95 (0.88–0.98)
DZF	47	23	97	0.90 (0.80–0.96)	30	33	92	0.72 (0.53–0.85)
DOS	57	57	146	0.75 (0.62–0.85)	38	42	132	0.75 (0.60–0.86)

Note. MZM, monozygotic males; DZM, dizygotic males; MZF, monozygotic females; DZF, dizygotic females; DOS, dizygotic opposite-sex twins.

suggesting more important shared environmental influences in boys who were raised religiously. In females, the same patterns of differences in twin pair correlations between the religious and the nonreligious groups were observed. In the religious group there is no difference between the MZ and the DZ twin correlations, suggesting a lack of genetic influences. In the nonreligious group, the correlations suggest both genetic and shared environmental influences.

Table IV shows the parameter estimates for the religious and nonreligious groups under the most general model. The corresponding proportions of the total variance in alcohol use initiation that can be explained by genetic and environmental factors is given in Table V. For both males and females a similar pattern emerged—there seemed to be reduced genetic influences and higher shared environmental influences in the religious group compared to the nonreligious group. Being raised religiously seemed to lower the impact of genetic influences, especially in girls.

In males, model-fitting analyses indicated that the differences in parameter estimates were not significant (Table VI). The genetic and environmental variances could be constrained to be equal between the religious and the nonreligious males without a significant reduction in the goodness of fit compared to the full model [model 4 vs model 1, $\Delta\chi^2(3) = 4.05$, $p = .26$]. For females, a model with equal unique environmental variances across the religious and nonreligious group and different familial variances did not fit the data [model 2 vs model 1, $\Delta\chi^2(1) = 5.40$, $p = .02$]. In fact, none of the parameters could be equated across groups (Table VI). Both genetic and environmental variances were significantly different between girls with and without a religious upbringing.

In sum, there is no statistical evidence that religious upbringing reduces the relative magnitude of the genetic influences on alcohol use initiation in males. The liability to alcohol use initiation in males was moderately influenced by genetic factors (30%; CI, 11–49%) and substantially influenced by shared environmental factors (60%; CI, 42–76%). For females however, the hypothesis that the relative magnitude of the genetic influences on the risk of alcohol use initiation would be greater for individuals who were raised in a less religious environment compared to individuals who were raised in a more religious environment was confirmed. The genetic influence on alcohol use initiation in nonreligious females was 40% (CI, 15–65%), compared to 0% (CI, 0–19%) in religiously raised females. Shared environmental influences accounted for 54% (CI, 30–77%) of the variance for nonreligious females and 88% (CI, 70–93%) of the variance in religious females.

DISCUSSION

In a large population-based sample of Dutch adolescent and young adult twins, 52% of the sample reported that they had a religious upbringing, and 48% reported that they were not raised religiously. We examined whether the twins who reported that they had a religious upbringing were less likely to drink alcohol than those who were not raised religiously. Although the differences between the two groups were in the predicted direction for both men and women, the differences were small and not statistically significant. Whether or not they were raised religiously, about 30% of the men and 38% of the women were lifetime abstainers from alcohol. Thus, we failed to replicate in

Table IV. Parameter Estimates Under the Most General Model for Additive Genetic Factors (h) and Common (c) and Unique (e) Environment as a Function of Religious Upbringing

	h	c	e	Total variance	Threshold
Males					
Religious	0.503	0.820	0.273	1	−0.50
Nonreligious	0.535	0.582	0.310	0.722	−0.50
Females					
Religious	0.000	0.937	0.349	1	−0.28
Nonreligious	0.455	0.546	0.171	0.535	−0.28

Table V. Percentage of Liability in Alcohol Use Initiation Explained by Additive Genetic Factors (h^2) and Common (c^2) and Unique (e^2) Environment for Males and Females as a Function of Religious Upbringing: Variance Components, with 95% Confidence Intervals in Parentheses

	h^2	c^2	e^2
Males			
Religious	25 (07–48)	67 (46–82)	7 (3–16)
Nonreligious	40 (05–69)	47 (20–76)	13 (6–26)
Females			
Religious	0 (0–17)	88 (72–92)	12 (7–19)
Nonreligious	39 (14–66)	56 (29–78)	5 (2–11)

Table VI. Tests of G×E Interaction for Alcohol Use Initiation

		Males		Females	
Model	df	χ^2	p	χ^2	p
(1) Full model:genetic and environmental variability	18	26.01	.10	26.01	.10
(2) Equal unique environmental variances	19	26.16	.13	31.41	.04
(3) Equal shared and unique environmental variances	20	29.95	.07	32.40	.04
(4) Equal familial variances (V_g and V_c)	20	28.79	.09	34.29	.02
(5) No interaction	21	30.06	.09	35.44	.03

this Dutch sample previous studies (e.g., Amey *et al.*, 1996) that have obtained a significant association between religiosity and alcohol use. At least among Dutch adolescents and young adults, religious upbringing does not appear to account for a significant portion of the shared environmental influences on the initiation of alcohol use. One of the most likely candidates for explaining the large shared environmental contribution to alcohol use, religious upbringing, may need to be ruled out, at least among Dutch adolescents and young adults.

It is unclear whether this failure to replicate previous studies conducted in the United States on the association between religiosity and alcohol use represents a cultural difference between Dutch and American adolescents and young adults. There are several important differences between the two countries that suggest that this might be the case. First, the religious composition of The Netherlands and the United States differs substantially in several ways. Only 25% of the Dutch population is Protestant, whereas 56% of the United States population belongs to this religious group [Central Intelligence Agency (CIA), 1998]. Thirty-six percent of the Dutch population is not affiliated with any religion, whereas only 10% of the United States population has no religious affiliation (CIA, 1998). Among the twins in the present study who were raised religiously and reported a current religious affiliation, 52% were Roman Catholic, 23% were Reformed, and 17% were Calvinist [the remainding 8% reported Islamic, Hindu, and "other" for their religious affiliation (Boomsma *et al.*,

1999)]. Thus, even among those who were raised in a religious environment, far fewer Dutch children than American children would have been raised in a religion that discourages or proscribes the use of alcohol.

Second, The Netherlands and the United States differ significantly with respect to official policies concerning the selling of alcohol to minors. In The Netherlands, the age at which it is legal to buy alcohol is 16, whereas in the United States the legal age to buy alcohol is 21 (World Health Organization, 1997). Thus, The Netherlands has much more liberal policies than the United States concerning the use of alcohol among youth. Third, The Netherlands and the U.S. populations differ in specific demographic characteristics that, at least in the United States, have been linked to rates of alcohol use. For example, only 11% of the population of The Netherlands resides in a rural area, whereas 24% of the U.S. population is rural-dwelling (World Health Organization, 1997). In sum, there are several reasons to believe that there may be real differences between The Netherlands and the United States in the correlates and causes of alcohol use initiation among youth.

We also examined whether being raised religiously would moderate the strength of the relative influence of genes on the risk for alcohol use initiation among Dutch adolescent and young adult twins. Religious upbringing reduced the influence of genetic factors on variation in alcohol use initiation. For religious males this reduction in the relative influence of genes was not statistically significant. Whether or not males were raised religiously, genetic factors explained 30% of the individual differences in risk for alcohol use initiation and shared environmental factors accounted for 60% of the variation. For females, we found significant differences in genetic and environmental variances between individuals who were raised religiously and individuals without a religious upbringing. In religiously raised women, the influence of genes was reduced to zero. The familial resemblances in the risk for alcohol use initiation in these women was explained by shared environmental factors, accounting for 88% of the total variance. For women without a religious upbringing, genetic factors explained 40% of the variance in risk of alcohol use initiation, and 54% of the variance was explained by shared environmental factors.

We obtained evidence consistent with a report by Heath *et al.*, (1985) that environmental effects attenuate genetic influences; in our data, religious participation moderates the genetic influences on the risk of alcohol use initiation, especially in females. In a previous study using this same sample, Boomsma *et al.*, (1999) found that religious upbringing significantly moderated the magnitude of genetic influences on the personality trait of behavioral disinhibition, with a smaller estimate of the importance of genetic influences for those who were raised religiously than those who were not raised religiously. Thus, religious upbringing not only reduces the impact of the genotype on disinhibited behavior (which includes more heavy and problematic alcohol use), but also reduces genetic influences on initiation of alcohol use.

ACKNOWLEDGMENTS

This work was supported by the Netherlands Organization for Scientific Research (NWO Grant 904-61-072), by the Free University (Grant USF96/22), and by the National Institute on Alcohol Abuse and Alcoholism (Grant AA00264).

REFERENCES

Amey, C. H., Albrecht, S. L., and Miller, M. K. (1996). Racial differences in adolescent drug use: The impact of religion. *Subst. Use Misuse* **31**:1311–1332.

CBS, Centraal Bureau voor de Statistiek (1999). *Jeugd, feiten en cijfers,* Voorburg/Heerlen, The Netherlands.

Central Intelligence Agency (1998). *World Factbook.*

Boomsma, D. I., Koopmans, J. R., van Doornen, L. J. P., and Orlebeke, J. F. (1994). Genetic and social influences on starting to smoke: a study of Dutch adolescent twins and their parents. *Addiction* **89**:219–226.

Boomsma, D. I., de Geus, E. J. C, van Baal, G. C. M., and Koopmans, J. R. (1999). A religious upbringing reduces the influence of genetic factors on disinhibition: Evidence for interaction between genotype and environment on personality. *Twin Res.* **2**:115–125.

Eaves, L. J., Martin, N. G., and Heath, A. C. (1990). Religious affiliation in twins and their parents: Testing a model of cultural inheritance. *Behav. Genet.* **20**:1–22.

Falconer, D. S. (1989). *Introduction to Quantitative Genetics,* 3rd ed., Longman Group, Essex.

Han, C., McGue, M. K., and Iacono, W. G. (1999). Lifetime tobacco, alcohol and other substance use in adolescent Minnesota twins: Univariate and multivariate behavioral genetic analyses. *Addiction* **94**:981–993.

Heath, A. C., and Martin, N. G. (1988). Teenage alcohol use in the Australian Twin Register: Genetic and social determinants of starting to drink. *Alcohol. Clin. Exp. Res.* **12**:735–741.

Heath, A. C., Berg, K., Eaves, L. J., Solaas, M. H., Corey, L. A., Sundet, J., Magnus, P., and Nance, W. E. (1985). Education policy and the heritability of educational attainment. *Nature* **314**: 734–736.

Heath, A. C., Jardine, R., and Martin, N. G. (1989). Interactive effects of genotype and social environment on alcohol consumption in female twins. *J. Stud. Alcohol* **50**:38–48.

Heath, A. C., Madden, P. A. F., Grant, J. D., McLaughlin, T. L., Todorov, A. A., and Bucholz, K. K. (1999). Resiliency factors protecting against teenage alcohol use and smoking: Influences

of religion, religious involvement and values, and ethnicity in the Missouri Adolescent Female Twin Study. *Twin Res.* **2:**145–155.

Koopmans, J. R., and Boomsma, D. I. (1996). Familial resemblances in alcohol use: genetic or cultural transmission? *J. Stud. Alcohol* **57:**19–28.

Koopmans, J. R., Heath, A. C., van Doornen, L. J. P., and Boomsma, D. I. (1997). The relation between sensation seeking, alcohol use and smoking: a multivariate genetic analysis. In Koopmans, J. R., *The Genetics of Health-Related Behaviors, a Study of Adolescent Twins and Their Parents,* Dissertation, Vrije Universiteit, Amsterdam.

Loehlin, J. C. (1972). An analysis of alcohol-related questionaire items from the National Merit Twin Study. *Ann. N.Y. Acad. Sci.* **197:**117–120.

Maes, H. M., Woodard, C. E., Murrelle, L., Meyer, J. M., Silberg, J. L., Hewitt, J. K., Rutter, M., Simonoff, E., Pickles, A., Carbonneau, R., Neale, M. C., and Eaves, L. J. (1999). Tobacco, alcohol and drug use in eight- to sixteen-year-old twins: The Virginia Twin Study of Adolescent Behavioral Development. *J. Stud. Alcohol* **60:**293–305.

Midanik, L. T., and Clark, W. B. (1994). The demographic distribution of U.S. drinking patterns in 1990: Description and trends from 1984. *Am. J. Public Health* **84:**1218–1222.

Neale, M. C. (1997). *Statistical Modeling with Mx,* Department of Human Genetics, Box 3, MCV, Richmond VA 23298.

Neale, M. C., and Cardon, L. R. (1992). *Methodology for genetic studies of twins and families* (NATO ASI Series D: Behavioral and Social Sciences, Vol. 67), Kluwer Academic, Dordrecht, The Netherlands.

Rose, R. J., Kaprio, J., Winter, T., Koskenvuo, M., and Viken, R. J. (1999). Familial and socioregional environmental effects on abstinence from alcohol at age sixteen. *J. Stud. Alcohol Suppl.* **13:**63–74.

World Health Organization (1997). *Tobacco or Health: A Global Status Report,* WHO, Geneva.

Edited by Richard J. Rose